

Report to the GTAP Advisory Board 2015

The Agricultural Economic Research Institute (LEI), part of Wageningen University (WUR), has been a member of the GTAP consortium since November 1996. We use the GTAP database and model for a variety of research activities related to the agri-food sector and beyond.

In particular, the standard GTAP model constitutes the basis of the MAGNET model, a modular CGE model approach developed at LEI. Hence the name MAGNET, short for "Modular Applied GeNeral Equilibrium Tool". MAGNET has the standard GTAP model at its core with all extensions added in a modular fashion. It allows the user to select which additional modules he/she wishes to include by adjusting the model settings and by including the relevant data. See annex 2 for an overview of the current structure of the MAGNET model.

Apart LEI from MAGNET is used and developed by researchers from IPTS and TI, with cooperation organized in a MAGNET consortium. A website has been launched (<http://www.magnet-model.org/>) providing access to project information, module descriptions and publications. To consolidate and develop MAGNET, we continue to hold regular update meetings and research seminars at LEI to present research and address specific issues in depth.

The following presents a summary of the activities of the MAGNET group at LEI in 2014/2015.

People

In 2014 Geert Woltjers and Gideon Kruseman unfortunately left the MAGNET team. New people joined the MAGNET team: Monika Verma, Jason Levin-Koopman and George Philippidis. Monika joined LEI in autumn 2014. She will be working on food loss and waste, trade and household modelling. Jason (currently finishing a PhD at the VU University Amsterdam) will focus on water issues and on the sustainable implementation of biofuel subsidies as well as their possible externalities, specifically regarding food security, land use change and the income of farmers. George joined in May 2015 and will focus on the Common Agricultural Policy (CAP), agri-food baselines and climate change policies.

Annex 1 gives an overview of current team members and main research interests in relation to CGE modelling with GTAP/MAGNET.

Marijke Kuiper, Lindsay Shutes (currently on maternity leave) and Andrzej Tabeau have been managing the MAGNET team at LEI. They have been given the task of coordination and programming activities in the GTAP/MAGNET work on a day to day basis. Hans van Meijl remains the scientific leader and contact person for GTAP/MAGNET work.

Team members contribute to the GTAP conference (paper on household modeling with food security scenarios). Furthermore, Heleen Bartelings and Zuzana Kristkova will attend the dynamic GTAP short course in summer 2015.

Looking ahead– focus areas for the coming year

The sizeable group of researchers involved with MAGNET work makes it worthwhile to exploit potential economies of scale, overcoming limits posed by project-driven research as done at LEI. For the coming year work on the following cross-cutting themes is planned, funded by a range of projects (more details can be found under CGE-related research).

- *Bio-based economy*: to better capture the economic and environmental implications of the bio-based economy more sector detail on bio-based and electricity sectors have been added to the database (about 20 new sectors in total) as well as a model extensions for residue supply and GHG emissions. These developments will be tested in a high-profile study to assess the macro-economic impact of the bioeconomy for the Netherlands and in a global focused analysis of the prospects for new bio-based technologies.
- *Food and nutrition*: recent developments in incorporating macro-nutrient flows from farm to fork, food losses and waste, and adding household level detail will be tested with dedicated food security scenarios with a focus on developing countries. Developments will continue on analyzing diets, food and nutrition security and food waste with a more European focus (SUSFANS project).
- *Food security and environment nexus*: exploiting the modular character of MAGNET we will analyze the food security implications of the bio-based economy; i.e. combine the two main

strands of developments of MAGNET to assess potential food security/environment trade-offs.

- *Energy and Climate Change*: detailed energy sectors (including renewable electricity sectors wind, solar and biomass) will be added and in combination with the new bioeconomy and emission modules IPCC scenario's will be quantified to 2050. Mitigation and adaptation scenario's will be assessed.

CGE-related research in 2014/2015

Land supply

- Recalibration and revision of land supply elasticities. Programming calibration procedure of this function.
- Improvement of agricultural land availability estimates – using newly developed data provided by the Dutch Environmental Agency (PBL). Assisting PBL on this research.
- Sources for update of exogenous land productivity used in projections are exploited including the OECD-FAO agricultural outlook for the medium-term, FAO's work on long term projections, econometric estimates using time series data. New estimates are implemented in several scenarios.
- Impact of climate change on yields was estimated and its consequences for agri-food sector were investigated.

Fertilizer modeling

- Literature research on modeling approaches of fertilizers and fertilizer policies
- Splitting up the GTAP p_c sector to three fertilizer sectors (N, P and K) and rest of p_c
- The database on fertilizers is gradually enhanced with data on fertilizer use per crop and per country
- Production trees of the production version have been modified so as to capture substitution between land and fertilizer use for crop production accounting hence for intensification vs. extensification of agricultural production systems
- Sensitivity analysis of substitution elasticity
- Emissions of fertilizers are calculated

Data and model management software

- GTREE: Created possibility to substitute strings in order to be able to use subroutines where some sets, coefficients or variables are substituted with a different name.
- Electricity split
 - Electricity has been split into 5 electricity sectors: electricity from (1) coal, (2) gas, (3) nuclear, (4) solar and wind (5) hydro and thermal
 - The old electricity sector is now a transport sector of electricity
 - Emissions attributed to the different electricity sectors have been calculated
- Split second generation biofuels and biochemicals
 - MAGNET has been expanded with several new biobased sectors: 1. Second generation biofuels gasification/thermal conversion technologies, 2. Second generation biofuel biochemical conversion technologies, 3. Bioelectricity, 4. Biochemicals, 5. Residues, 6. Dedicated energy crop plantations (woody and/or grassy crops) and 7. Biomass pretreatment sectors. Two types of residues are considered: 1. Forest residues and 2. Agricultural residues.
 - The price of residues is calculated based on an asymptote meaning that the price of residues is low when little of the capacity is used and very high when almost all potential of residues is used. The relation between demand and price is non-linear.

Emission module

- Magnet has been extended with an emission module.
- Both CO₂ and Non-CO₂ emissions published by GTAP have been included.
- Emissions for the newly introduced biofuel sectors, fertilizer sectors and energy sectors are also calculated.
- The emission module makes it possible to solve MAGNET either with a CO₂ tax or with an emission reduction target.
- Incorporating emission quota trading is under way.

Linking of models and long term scenario development

- **VOLANTE: Visions Of LAND use Transitions in Europe:** The scenario outcomes were confronted with stakeholder's visions of sustainable land future and LEI actively participates in this process. As the result, pathways (roadmaps) to reach the desired future of European land development and land use management are identified.
- **AgMIP:** Comparison of alternative approaches for long-term scenarios for agricultural markets and trade
 - The LEI/MAGNET and PBL/IMAGE teams are busy with quantification of RAPs (Representative agricultural pathways) and climate scenarios. The SSP1, 2 and 3 story lines and macro-economic assumptions are used. Teams involved are GCAM, AIM, IIASA (GLOBIOM for land use part), PIK (Remind-MagPie). For IPTS mitigation and adaptation scenario's are analysed by LEI\PBL (MAGNET-IMAGE), IIASA (Globiom), PIK (Magpie) and UniBonn (CAPRI).
 - Five global economic models (ENVISAGE, FARM, MAGNET, IMPACT and MAGPIE) with a focus on agriculture were used to analyze climate impacts on agri-food-sectors in combination with the three SSPs and their associated changes in crop- and region-specific changes in agricultural productivity. Also, it was investigated whether the impacts of climate change would differ if restrictive trade policies would be in place or if trade would be liberalized.
- **OECD Long-Term Scenarios food and agriculture:** Three scenarios describing three different futures of world economy in general and agricultural sector in particular were developed. They cover a relevant part of the possible scenario space by being sufficiently distinct from each other. They describe very different developments for the various key uncertainties that are believed to drive food and agriculture systems. Therefore, these three marker scenarios differ by different projected economic and population development, different levels on integration and liberalization of world economy and different future visions of climate change. The scenarios were run using MAGNET. IMPACT, ENVISAGE and GLOBIOM models for 2007-2050 period. Key challenges/concerns related to marker scenarios were identified. Related policy options dealing with these challenges were addressed. To quantify the potential impacts of policy strategies on key target issues, the policy related scenarios were run on the top of previously developed marker scenarios.

Impacts of trade policies: tariffs and non-tariff measures

- Tariff shocks are handled at 6 digit level instead of the GTAP aggregation, applying shocks on bound tariffs instead of applied tariffs when necessary.
- Application of MAGNET for assessing trade policies (focus agri-food trade), in particular tariff and NTM liberalisation (state of the art methods)
- Investigation of TTIP (also analysis of TTIP on households in developing countries, see household modelling), and EU DCFTAs with CIS countries.

Impacts of bioenergy production and use

- Land use effects of biofuel use in Brazil (BE Basic project): Biofuel production and use scenarios have been developed and implemented in MAGNET to analyze the impacts of biofuel policies on land use changes in Brazil. MAGNET is soft-linked to a spatial allocation model PLUC, which is applied in this exercise for Brazil and uses land demand changes derived from MAGNET. MAGNET is integrated with BLUM partial equilibrium model of the Brazilian agricultural sector and biofuel sectors. This project is carried out together with Agricultura, Energia e Sustentabilidade (ICONE) in Sao Paulo (Brazil) and Utrecht University.
- Biofuel production and use scenarios will be developed and implemented in MAGNET to analyze the impacts of biofuel policies on food security at the global level and in specific regions and countries, including Ghana. Specific attention will be given to strategies aimed at reducing negative impacts on food security. The analyses will be done at household level, possibly results will be given for nutritional values. This project is carried out in collaboration with Utrecht University.
- MAGNET is used to evaluate the land use change and food security effects of the use of residues and waste, using the sustainable potential of wheat straw for energy production in the EU in 2030 as a case study. This is done based on a shock of output subsidies. This project is carried out in collaboration with the Netherlands Environmental Assessment Agency. A similar analysis is done for the world.
- MAGNET is used to evaluate the economic impacts of biobased technologies in the EU. These technologies are considered in MAGNET by means of shift in technology as also

applied in the study 'Macro-economic Impact Study for Biobased Malaysia' LEI report 2012-042 <http://edepot.wur.nl/274714>. This project is in collaboration with the Netherlands Environmental Assessment Agency and the Institute for Prospective Technological Studies of the EC. An update of this study is currently ongoing.

Household modeling

- The modular set-up in MAGNET now allows the household module to be activated by model region (choosing either a regional household as in GTAP, a split between a single private household and government with no overarching regional household, or multiple households and a government) and combined with the other modules in MAGNET (like endogenous land supply, biofuels etc.).
- The household module is currently being used for various studies: the impact of climate change on the poor in Ghana, impact of biofuel directives on households in developing countries, the impact of TTIP on households in developing countries.

Global household database

- The current version of the household module allows for the separation of the government and private household for all regions; such that all tax revenues accrue to government and factor payments accrue to the private household and government. Transfers between the government and private household are explicitly included. A procedure for introducing different household types using publicly available national SAMs has been developed and is described in a FoodSecure technical paper (Kuijper and Shutes, 2014).
- Our ambition is one of broad but global coverage, i.e. we aim for a global database compatible with any GTAP version, constructed from public data sources. Our intention is to make the source data and procedures we use publicly available to solicit feedback on our approach and invite others to contribute data.
- A short-list of priority countries has been developed using the criteria of data availability, food and nutrition status, whether a country is identified individually in the GTAP database and whether it is a FOODSECURE case study country (a key funder of this work). This process resulted in a short-list of Ghana, Kenya, Uganda, India (completed), Indonesia, and Ethiopia (ongoing).

Food security

- The household data procedures also allow a split of standard GTAP factors using national SAM data, providing a more detailed assessment of the distributional consequences of macroeconomic changes.
- Stakeholders participating in the FoodSecure project (www.foodsecure.eu) felt that these SSP scenarios do not adequately account for aspects relevant to food and nutrition security. To address these concerns four scenarios focussing on food security developments up to 2050 are developed in the FoodSecure project. These scenarios coincide with quantification of the SSP scenarios where possible, while diverging where needed to capture developments deemed critical for analysing food and nutrition security. The four scenarios are developed along two axes (sustainability and equality) with an emphasis on either private or public domains taken into account within the scenarios. Work is ongoing to quantify and test these scenarios with MAGNET.

Consumption and nutrition

- Nutrition indicators developed earlier have been integrated with household module making nutrition indicators available by household type and are part of the indicators used in the scenarios developed as part of FoodSecure.

Technical change

- Estimation and implementation of technology shifters in MAGNET
- Land-augmenting technical change in agriculture is linked to public agricultural R&D investments in a new R&D module (see below)

Modeling R&D investments

R&D in MAGNET is distinguished between public R&D and private R&D. The first step focused on incorporating public R&D investments (as they still represent the most important source of R&D financing in agriculture). Given that public R&D is produced in public institutes (contrary to private R&D that has more an "in-house" character), a specific public R&D sector was disaggregated from

other public services sectors (following the same cost structure). Public R&D is demanded by government and it grows according the growth of agricultural GDP (the share of R&D expenditures in agricultural VA remains constant over time). Growth of R&D investment is translated to productivity via accumulation of R&D stock. R&D stock is modelled using a gamma distribution function which counts with long-term lag of R&D effects (max 50 years and peak years between 3 - 24 years depending the vintage group). Finally, land-augmenting technical change grows according the growth rate of domestic R&D stock and growth rate of R&D spillovers modelled as a function of regions' production similarity, agro-ecological conditions similarity and level of absorption. For the upcoming year, the modeling task will be concentrated on two issues:

- 1) Continuation with empirical estimation of R&D driven technical change in agriculture, following the empirical research on 10 sectors done last year (important for credible values of R&D elasticities in a land equation) and
- 2) Incorporation of private R&D activities in Magnet and their link to factor augmenting technical change.

MAGNET related 2014/2015 publications

Journal articles & book chapters:

- Koopman, J.F.L., Kuik, O.J., Tol, R.S.J. and R. Brouwer (2015). Water scarcity from climate change and adaptation response in an international river basin context. *Climate Change Economics* 6:1 doi: 10.1142/S2010007815500049 <http://www.worldscientific.com/doi/pdf/10.1142/S2010007815500049>
- Koopman, J.F.L., Kuik, O.J., Tol, R.S.J. and R. Brouwer (2015). The potential of water markets to allocate water between industry, agriculture and public water utilities as an adaptation mechanism to climate change. Submitted.
- Smeets Kristkova, Z., Gardebroek, K., Van Meijl, H., Van Dijk, M. (2014). The Impact of R&D on factor-augmenting technical change - an empirical assessment at the sector level. Submitted.
- Edward Smeets, Andrzej Tabeau, Siemen van Berkum, Jamil Moorad, Hans van Meijl and Geert Woltjer (2014). "The impact of the rebound effect of the use of first generation biofuels in the EU on greenhouses emissions: A critical review", *Renewable and Sustainable Energy Reviews* 38 (2014) 393-403. <http://www.sciencedirect.com/science/article/pii/S1364032114003608>.
- Koen P. Overmars, Elke Stehfest, Andrzej Tabeau, Hans van Meijl, Angelica Mendoza Beltrán and Tom Kram (2014). "Estimating the opportunity costs of reducing carbon dioxide emissions via avoided deforestation, using integrated assessment modelling", *Land Use Policy*, Volume 41, November 2014, Pages 45-60, <http://www.sciencedirect.com/science/article/pii/S0264837714000799>.
- Elke Stehfest, Hans van Meijl, Anne Gerdien Prins, Andrzej Tabea (2014). "Agricultural economy", in: Elke Stehfest, Detlef van Vuuren, Tom Kram, Lex Bouwman (eds), "Integrated Assessment of Global Environmental Change with IMAGE 3.0. Model description and policy applications", PBL Netherlands Environmental Assessment Agency, The Hague, 2014. [http://www.pbl.nl/sites/default/files/cms/publicaties/PBL-2014-Integrated Assessment of Global Environmental Change with IMAGE 30-735.pdf](http://www.pbl.nl/sites/default/files/cms/publicaties/PBL-2014-Integrated%20Assessment%20of%20Global%20Environmental%20Change%20with%20IMAGE%2030-735.pdf)
- Aikaterini Kavallari, Edward Smeets, Andrzej Tabeau (2014). "Land use changes from EU biofuel use: a sensitivity analysis", *Operational Research*, July 2014, Volume 14, Issue 2, pp 261-281.
- Edward Smeets, Andrzej Tabeau, Corjan Brink, Anne Gerdien Prins, Marijke Kuiper, Geert Woltjer and Hans van Meijl (2014). "Evaluating the land use change and food security effects of the use of residues and waste for bioenergy production", *Biomass and Bioenergy*. Submitted.
- Valin, H., Sands, R. D., van der Mensbrugge, D., Nelson, G. C., Ahammad, H., Blanc, E., Bodirsky, B., Fujimori, S., Hasegawa, T., Havlik, P., Heyhoe, E., Kyle, P., Mason-D'Croz, D., Paltsev, S., Rolinski, S., Tabeau, A., van Meijl, H., von Lampe, M. and Willenbockel, D. (2014), The future of food demand: understanding differences in global economic models. *Agricultural Economics*, 45: 51-67. doi: 10.1111/agec.12089, <http://onlinelibrary.wiley.com/doi/10.1111/agec.12092/pdf>
- Robinson, S., van Meijl, H., Willenbockel, D., Valin, H., Fujimori, S., Masui, T., Sands, R., Wise, M., Calvin, K., Havlik, P., Mason d'Croz, D., Tabeau, A., Kavallari, A., Schmitz, C., Dietrich, J. P. and von Lampe, M. (2014), Comparing supply-side specifications in models of global

- agriculture and the food system. *Agricultural Economics*, 45: 21–35. doi: 10.1111/agec.12087, <http://onlinelibrary.wiley.com/doi/10.1111/agec.12087/pdf>
- Nelson, G. C., van der Mensbrugghe, D., Ahammad, H., Blanc, E., Calvin, K., Hasegawa, T., Havlik, P., Heyhoe, E., Kyle, P., Lotze-Campen, H., von Lampe, M., Mason d'Croz, D., van Meijl, H., Müller, C., Reilly, J., Robertson, R., Sands, R. D., Schmitz, C., Tabeau, A., Takahashi, K., Valin, H. and Willenbockel, D. (2014), Agriculture and climate change in global scenarios: why don't the models agree. *Agricultural Economics*, 45: 85–101. doi: 10.1111/agec.12091, <http://onlinelibrary.wiley.com/doi/10.1111/agec.12091/pdf>
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 - Dijk van, M., 2014. Productivity growth at the sectoral level: measurement and projections (submitted).
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 - Meijl, H., Smeets, E., Dijk van, M., Powell, J., Tabeau, A., 2014. Macro-economic impact study for Bio-based Malaysia (submitted).
 - Schmitz, C., van Meijl, H., Kyle, P., Nelson, G. C., Fujimori, S., Gurgel, A., Havlik, P., Heyhoe, E., d'Croz, D. M., Popp, A., Sands, R., Tabeau, A., van der Mensbrugghe, D., von Lampe, M., Wise, M., Blanc, E., Hasegawa, T., Kavallari, A. and Valin, H. (2014), Land-use change trajectories up to 2050: insights from a global agro-economic model comparison. *Agricultural Economics*, 45: 69–84. doi: 10.1111/agec.12090, <http://onlinelibrary.wiley.com/doi/10.1111/agec.12090/pdf>
 - Powell, J., K. Shutes and A. Tabeau, Effects of changing weather patterns on the trade of major food crops. Submitted March, 2014.
 - Rutten, M., M. van Dijk, W. van Rooij, and H. Hilderink (2014), "Land Use Dynamics, Climate Change and Food Security in Vietnam: a Global-to-Local Modeling Approach", *World Development*, 59, July 2014: 29-46.
 - von Lampe, M., Willenbockel, D., Ahammad, H., Blanc, E., Cai, Y., Calvin, K., Fujimori, S., Hasegawa, T., Havlik, P., Heyhoe, E., Kyle, P., Lotze-Campen, H., Mason d'Croz, D., Nelson, G. C., Sands, R. D., Schmitz, C., Tabeau, A., Valin, H., van der Mensbrugghe, D. and van Meijl, H. (2014), Why do global long-term scenarios for agriculture differ? An overview of the AgMIP Global Economic Model Intercomparison. *Agricultural Economics*, 45: 3–20. doi: 10.1111/agec.12086, <http://onlinelibrary.wiley.com/doi/10.1111/agec.12086/pdf>

Conference papers

- Kuiper, M.H, van Dijk, M., Shutes, L. (2015). Exploring different food security futures, what might be in store for the poor in Ghana? Paper presented at the 18th Annual Conference on Global Economic Analysis "Information for the Policy Maker: Practical Economic Modelling for Tomorrow", Melbourne June 17-19, 2015.
- Smeets Kristkova, Z., Van Meijl, H. and M. van Dijk (2015). Impact of innovation policy and technology transfer on long-term food security. Paper prepared for the presentation at the Conference on Food in the Bio-based Economy; Sustainable Provision and Access, Wageningen University, May 27 – 29, 2015.
- Edward Smeets, Andrzej Tabeau, Hans van Meijl (2015). "A global assessment of the land use change and food security effects of the use of agricultural residues for bioenergy production", conference paper prepared for the Conference on Food in the Bio-based Economy; Sustainable Provision and Access, May 27 – 29, 2015 Wageningen University, Wageningen, The Netherlands and for the conference "Impacts of the Bioeconomy on Agricultural Sustainability", ICABR, June 16 – 19, Ravello, Italy.
- Hans van Meijl, Edward Smeets, Michiel van Dijk, Geert Woltjer, Andrzej Tabeau, Aikaterini Kavallari, 2014. "The bioeconomy: the macro-economic impact of using residues and by-products of palm oil production", European Association of Agricultural Economists Congress, August 26-29, Ljubljana, Slovenia.

- Rau, M.-L. (2014). Conquering the EU market with new comprehensive trade agreements - simulating DCFTAs between the EU and neighbour countries, European Association of Agricultural Economists Congress, August 26-29, Ljubljana, Slovenia.
- Smeets Kristkova, Z., Gardebroek, K., Van Meijl, H. and M. van Dijk (2014). The Impact of R&D on factor-augmenting technical change - an empirical assessment at the sector level. Paper presented at International Conference on Economic Modeling, EcoMod 2014, July 16 – July 18. Bali, Indonesia.
- Dijk van, M., Woltjer, G., Philippidis, G. (2014). Validating CGE models employing an historical approach. Presented at the 17th Annual Conference on Global Economic Analysis, Dakar, Senegal.

Reports & working papers

- Woltjer, G.B., Kuiper, M., Kavallari, A., Meijl, H. van, Powell, J.P., Rutten, M.M., Shutes, L.J., and A. Tabeau (2014). The MAGNET Model: Module description. The Hague: LEI Wageningen UR, 2014 (LEI Report 14-057).
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- Kuiper, M.H. and L. Shutes (2014). Expanding the household coverage of global simulation models: An application to Ghana. FOODSECURE Technical paper no. 3, December 2014. www.foodsecure.eu.
- John Helming, Heleen Bartelings, Edward Smeets, et al., 2015. "D3: The biomass processing sectors in MAGNET". The Enhancement of the MAGNET model: fertilizers and biobased sectors; European Commission AGECONEUROPE framework contract.
- Hermann Lotze-Campen, Peter Verburg, Alex Popp, Marcus Lindner, Hans Verkerk, Alex Moiseyev, Elizabeth Schrammeijer John Helming, Andrzej Tabeau, Nynke Schulp, Emma van der Zanden, Carlo Lavalle, Filipe Batista e Silva, David Eitelberg, Ariane Walz, 2014. "A cross-scale impact assessment of European nature protection policies", Deliverable No: 7.4, VOLANTE project, EC Contract Ref: FP7-ENV-2010-265104.
- Shutes, L. , E. Smeets and H. van Meijl (2014). A theoretical economic framework for measuring the food security impacts of biomass production. Report for the BE-BASIC project, *forthcoming*.
- Tabeau, A., M. Rutten and F. Godeschalk (2014), "Per-capita calorie consumption in IMAGE regions of MAGNET in the long-run", Deliverable 2 for project 'Project 'MAGNET Consumption and Calorie Indicators', Client: Environmental Assessment Agency of the Netherlands (PBL).

Annex 1 – MAGNET team at LEI



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- Food security
- Climate Change



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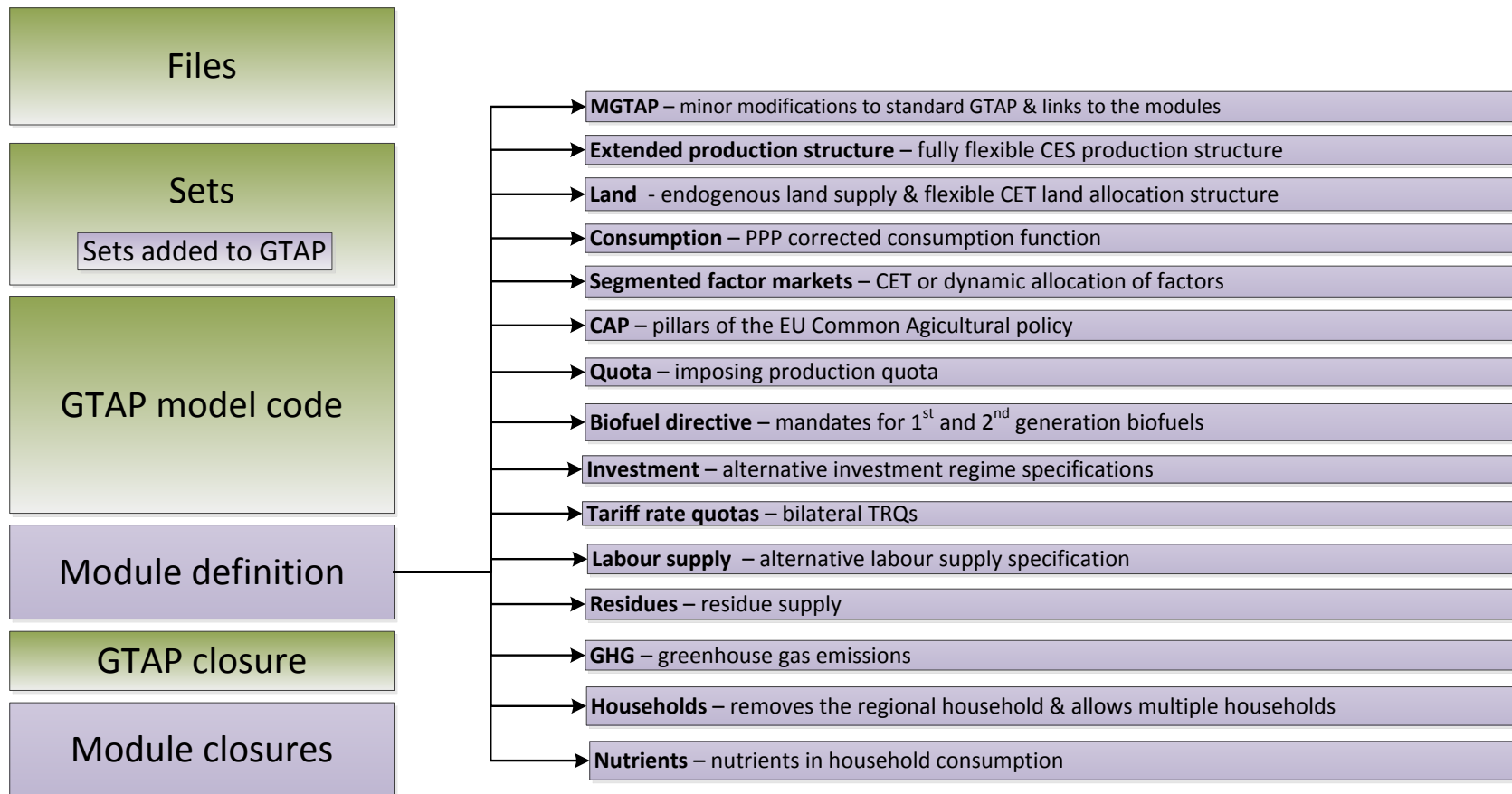


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- Software development

Annex 2: Overview of the structure of the MAGNET model



Key:-

